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BAYER LEVERKUSEN (GERMANY)
Department for Crop Protection

Forecasting the occurrence of spinach leaf miners in 1958, based on studies conducted from October 17 to 26, 1957

by L. Rump and A. Niemöller, Regional Pest Control Office, Mainz.

In 1957, the spinach leaf miner or mangold fly (*Pegomya hyoscyami* Panz.) occurred for the first time as a major pest in the sugar beet and fodder beet farming districts of Rhineland-Pfalz, in fact on such a large scale that the beet crops were seriously threatened with destruction. This sudden and unexpected mass occurrence of the pest was all the more surprising as it had not previously inflicted any significant damage and moreover it had never been necessary to apply control measures against the miner. Fortunately for the local beet farmers, the danger was recognised in good time from the unusually large number of eggs laid on the young beet plants so that the regional pest control office was able to issue special warnings to beet farmers drawing their attention to the necessity of adopting suitable control measures. The beet farmers followed the advice given by the local crop protection experts, and the success of the operation is illustrated by the fact that approximately 12 million litres of spray solution were applied giving most effective control of the spinach leaf miner, especially the first generation, with the result that no beet fields anywhere in the treated area had to be ploughed up and re-set. This success is all the more remarkable when it is considered that the control of the spinach leaf miner constitutes an additional crop protection practice which previously had never been necessary in Rhineland-Pfalz, and which cannot be combined with the spray applications that have to be carried out immediately afterwards against aphids to control beet yellows. But it must also be pointed out that the success of the spinach leaf miner control was rendered possible mainly by the fact that at the time this pest occurred spraying equipment provided by the regional pest control office was already distributed in the beet farming districts in readiness for the control of yellows, and thus facilitated the immediate implementation of such an extensive control operation against the miners.

At it cannot be assumed that there will be no repetition in 1958 of the mass occurrence of spinach leaf miners on the dangerous scale experienced in 1957, it is the task of the regional pest control office to obtain data permitting a forecast to be made for the coming year. A report of this work is given on the following pages.

Injury and economic importance

Towards the end of April, whitish-yellow transparent mines appear in the leaves of young sugar beet and fodder beet plants, accompanied by the formation of blotches spread over the leaf surface. The leaf tissue is wanting at the

points where these blotches have formed and only the upper and lower leaf epidermis is still intact. A closer inspection reveals that some of these mines and blotches are filled with brown, crumbly excrement, and moreover a footless maggot is to be found in each. These are the maggots of the spinach leaf miner; after emerging from the elongated, cylindrical, white eggs laid on the lower surface of the leaves, they immediately begin to feed on the beet leaf and form mines. The hollowed-out leaves gradually dry up, turn brown and perish. In unfavourable weather conditions the young beet plants die due to the destruction of leaf substance. Usually, however, the heart leaves which are not yet developed remain uninjured, and the beet plant forms new leaves. This injury may be repeated in early July and the middle of August when the outer leaves are re-attacked by a second and a third generation of spinach leaf miners.

The injuries inflicted by the spinach leaf miner larva is especially great on those beet plants still in an early stage of growth because practically half the foliage is often destroyed with the result that the beets are frequently disfigured and damaged so seriously that it may be necessary to plough up the field and set a new crop. When controls are not carried out, the beet yield in the main districts of pest occurrence may be reduced to a third or a quarter due to the destruction of tops. In years of very severe infestation, harvest losses of even 70 % have been recorded especially in areas where the spinach leaf miner occurs annually and mass reproduction of the pest is not checked by suitable control practices.

Biology of the spinach leaf miner

The spinach leaf miner resembles the house fly although it is somewhat smaller (6 to 7 mm long) and more slender than the latter (Fig. 1). It is lightly bristled, and depending upon the host plant on which the larva develops, its body is light grey to dark green. It has large red eyes which in the male almost meet at the vertex. It is easy to distinguish from the house fly by virtue of its completely divergent venation of the slightly yellowish wing.

In the female, the eyes are well apart, and the centre of the frons has a streaky yellow to brown tone. The thorax of the fly features three or five dark longitudinal stripes; there is one dark longitudinal stripe on the reddish-yellow to grey dorsum. The legs are yellowish-red to yellow. The adult is very resistant to weather influences.

From the end of April until well into May, the female lays 50 to 90 eggs approximately 0.7 to 0.8 mm long; these are deposited singly or in batches in parallel files, nearly always on the lower leaf surfaces of young beet plants. The eggs are white, impervious to water, and feature a net-like structure on the outer surface. As the eggs are attached very firmly to the leaves, they are not washed away by water.

The larvae hatch out of the eggs after only four to six days, and then bore into the leaf immediately below the egg; they produce mines in the leaf by gnawing the parenchyma. The cylindrical, glassy to dirty-white coloured larva tapers off in structure to the front, and when fully grown attains a length of

7 to 8 mm. One leaf is frequently colonized by several larvae so that the system of mines produced expands in the shape of a fan. The blackish, granular excrement is spread in lumps in the hollowed-out parts of the leaves.

After two moults, the larva becomes fully developed in about 12 to 14 days and enters the ground to pupate about 2 to 5 centimetres below the surface.

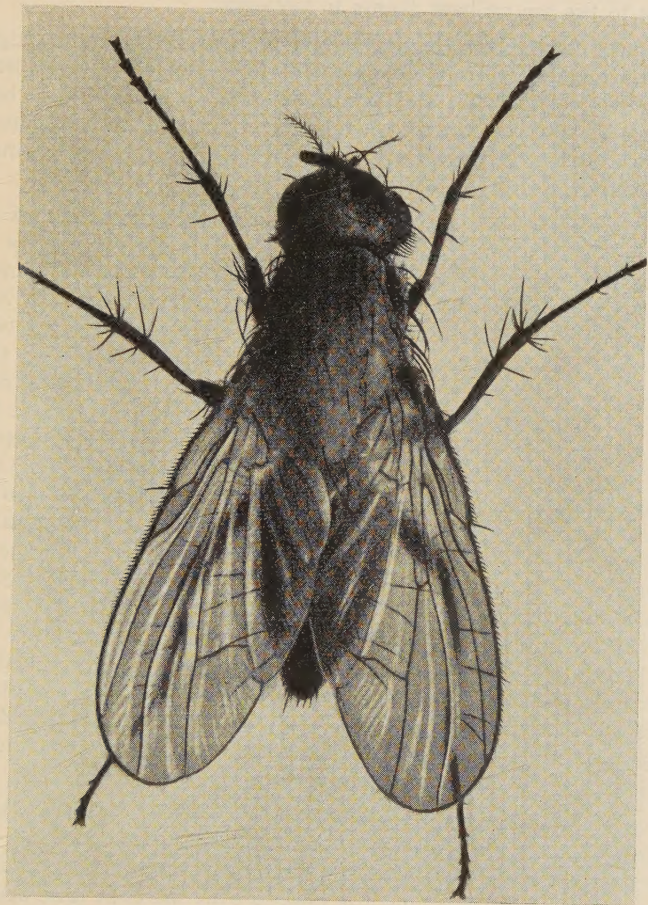


Fig. 1

The pupae are barrel-shaped, 5 to 6 mm long, 2 mm wide and reddish to chestnut-brown in colour.

The flies emerge after 2 to 4 weeks. Depending upon weather conditions, the total development of a generation takes 1 to 2 months. The flies are ready to lay eggs only a few days after emergence, and a new larval generation then

begins its work of destruction. Three generations may occur in favourable climatic conditions such as prevail during the summer months in Rhineland-Pfalz. The pupae overwinter in the beet field 2—5 centimetres below the ground surface, usually close to the beets. They are not affected by severely cold weather. They can also lie in water for lengthy periods without being harmed. The pupae begin to develop as soon as the soil becomes warm in Spring. The emerging flies then feed on hedges and vegetation at the edge of woods until they migrate to the young beet plants to lay eggs.

With respect to climatic factors, it has been established that high temperatures have a most favourable effect on the mass reproduction of the spinach leaf miner. However, rainfall and low temperatures, on the other hand, have an unfavourable and retarding influence on development, consequently also on mass reproduction. At temperatures above 32° C, the development of all spinach leaf miner stages is checked completely.

Natural enemies of the spinach leaf miner are ichneumon flies belonging to the families of Braconidae and Ichneumonidae, which frequently parasitize the larvae of the miner so that in favourable weather conditions mass reproduction of this pest is prevented by natural means. The insects of these parasites puncture the leaves with their ovipositors and at the same time pierce the spinach leaf miner larvae, laying their eggs in the bodies of the larvae. However, as the spinach leaf miner larva is still able to pupate despite the presence of the living parasite larva in its body, this latter continues to develop and also pupates in the miner larva. Externally, the parasitized spinach leaf miner pupae can be distinguished from those not parasitized because the former are black to blackish-brown whereas the latter have a chestnut-brown colour. These natural enemies of the spinach leaf miner are, however, greatly dependent upon weather factors so that the extent of parasitization fluctuates appreciably according to the prevailing weather. As the mass reproduction of the parasites is stimulated by high temperatures far more than the reproduction of the spinach leaf miners, in favourable weather a larger number of spinach leaf miner larvae are killed by the ichneumon flies. On the other hand, spinach leaf miners have better prospects of reproducing in years when the weather is cool because then the development of the predators is greatly checked and cannot keep pace with the mass reproduction of the spinach leaf miner which is less sensitive to the influence of temperature.

The severe occurrence of the spinach leaf miner last year made it necessary for the regional pest control office at Mainz to search for methods which will enable a repeat or more severe mass occurrence of spinach leaf miners to be recognised in good time. Now that the pest has for the first time caused severe damage to the young beet crops, it is most essential that beet farmers are given early warnings of expected attacks. During the previous vegetation season, the weather was relatively cool and wet, so that it is assumed that the parasitization of spinach leaf miners by natural enemies was not sufficiently extensive to check mass reproduction of the pest. However, in order to make any form of forecasts, it was necessary to establish the population density of spinach leaf miner pupae colonizing the soil in beet farming districts, and also to find out to what extent these pupae were parasitized.

Preparatory work for making a forecast of possible pest occurrence

As already mentioned, the spinach leaf miner larva usually pupates close to the beet plants. When the beets are uprooted, the pupae are carried with the soil clinging to the beets to the sugar factories; here the beets are washed and the pupae pass into the sludge beds and clarifying equipment. In the past the

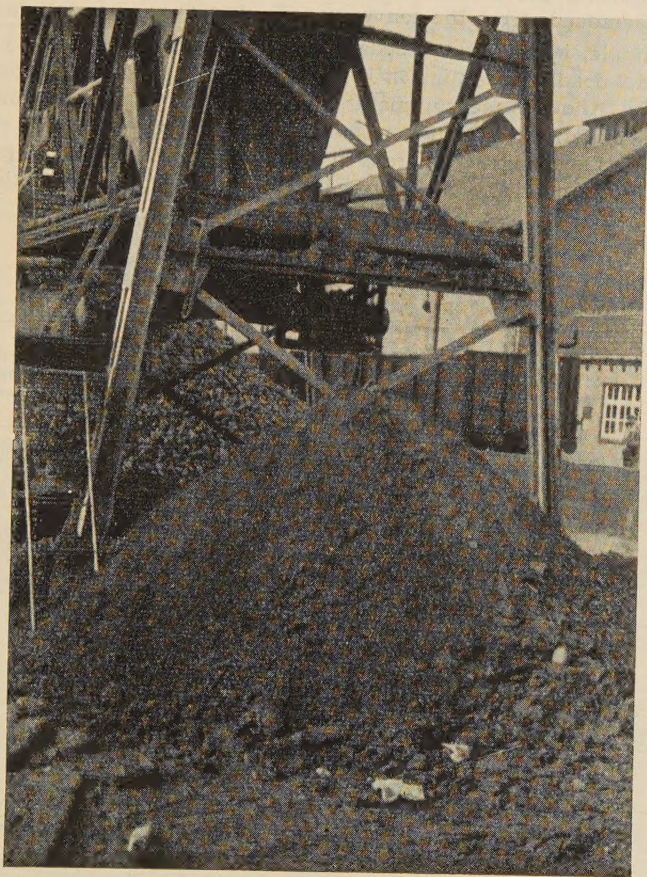


Fig. 2

regional pest control office at Mainz has had no records of experience as to how and to what extent pupae of spinach leaf miners could be found at the two sugar factories at Rheingau and Offstein. If pupae were present in the soil clinging to the processed beets, then a method would have to be devised of grouping any pupae found according to certain districts so that conclusions could be drawn on the degree of infestation in the different areas.

The work at the Rheingau sugar factory proved to be extremely difficult. The sludge beds spread out some distance away from the sugar factory in the Rhine Plain were not easily accessible, dangerously boggy and overgrown by tall plants of all kinds. Very few pupae were to be found at the natural gathering points in the sludge beds, for example in corners and on weeds. In fact only a few pupae were found in the feed channels in which screens 1 square metre in size had been installed to trap all dirt particles. Moreover, results obtained following the screening and washing processes from dirt particles falling in wagonloads from the conveyor belts (Fig. 2) were unsatisfactory.

For example, in the sludge beds of the Rheingau sugar factory 16 pupae (9 living and 7 dead) were found in 1½ square metres of sludge particles covering the beds. Another measurement gave 11 pupae (9 normal and 2 dead) per 1½ square metres. In a further case, 14 pupae (11 normal and 3 dead) were counted in 10 square metres, whereas in a wagonload of soil only 11 pupae were found (9 normal and 2 already emerged). These figures were of little practical

Table 1: Findings of spinach leaf miner pupae at the sugar factory at Rheingau, Worms

Sludge bed	Size of screened area in sq. metres	Total no. of pupae	No. of living pupae	No. of pupae dead or emerged	Reduced to sq. metre	Total no. of pupae	No. of living pupae	No. of pupae dead or emerged
	1.5	16	9	7	1	10.6	6.0	4.6
	1.5	11	9	2	1	7.4	6	1.4
	10	14	11	3	1	1.4	1.1	0.3
Pupae in wagon soil		11	9	2				
Pupae in wagon soil		9	6	3				
Pupae in wagon soil		4	3	1				

value for making a forecast of infestation for the coming year, so that these studies were stopped. At the time the studies were conducted, about 25 % of the beet crops had been supplied to the sugar factory. Table 1 gives a list of the findings at the sugar factory at Rheingau, Worms.

The conditions for carrying out research on this problem at the Offstein sugar factory were quite different and more favourable. At this factory there were two possible methods of washing beets and also two possibilities for finding pupae. The dirty water is piped off to two sludge beds located in separate areas. Three interconnected beds are located close to the sugar factory, to which

Table 2: Findings of spinach leaf miner larvae at the Offstein sugar factory.

Waste water	Residues in kilos	Total no. of pupae	No. of living pupae	No. of pupae destroyed or emerged	Reduction to kilo	Total no. of pupae	No. of living pupae	No. of pupae destroyed or emerged
Warm	5	280	104	176	1	56	21	35
Warm	1	76	47	29	1	76	47	29
Warm	1	48	27	21	1	48	27	21
Warm	1	57	20	37	1	57	20	37
Warm	5	207	108	99	1	41	21	20
Cold	10	439	222	217	1	43	22	21
Cold	3	64	35	29	1	21	11	10
Clarifying plants, cold	5	72	45	27	1	14	9	5
Clarifying plants, cold	5	23	13	10	1	5	3	2

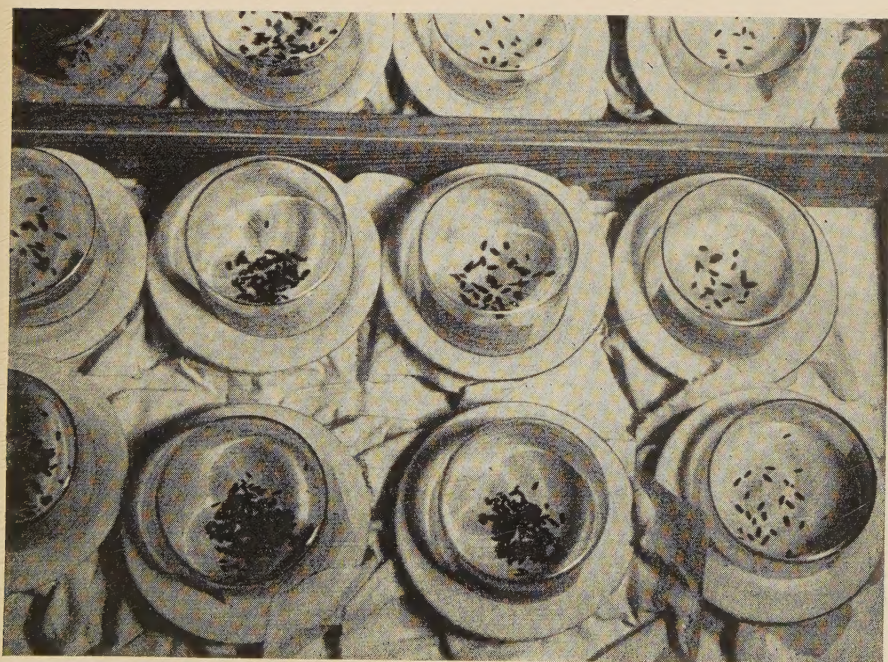


Fig. 3

the waste water at a temperature of 45°C is fed through specially constructed channels. At the inlets to these beds, several layers of sludge were superposed on the surface; an examination was made of these layers. There was a high percentage of pupae here, and it was an easy matter to quickly find a number of pupae in the residues from the beet wash. For example, 5 kilos of sludge and beet residues contained 280 pupae; of these 104 were apparently alive whereas the other 176 had in all probability been destroyed in the beet wash or were the remains of emerged pupae of earlier generations. More figures are given below in Table 2.

The sampled pupae were placed in separate special type culture vessels (Fig. 3) according to the times of discovery, with the object of studying their further development in the laboratory. The fact that the warm waste water constantly has a temperature of about 43°C means that there is the possibility of most of the pupae being killed by this hot water.

Another method of beet washing at this sugar factory is with cold water. The residues and sludge particles are piped off in special channels some considerable distance, and then seeped in special beds. This waste water was also examined because it contains the dirt residues from the waggons, which are flushed under strong water pressure in the drainpipes and fed away in the above-mentioned channels. Very large numbers of pupae were found here, for example 439 in 10 kilos of sludge; of these 222 were apparently living and the



Fig. 4



Fig. 5

other 217 were either dead or injured. Moreover very interesting and high results were obtained from the beet residues examined at the large clarifying plants of the factory (Fig. 4); 72 pupae were found in 5 kilos of sludge. Table 2 gives the numbers of pupae found.

The spinach leaf miner pupae found at the Offstein sugar factory could not, however, be traced back to the fields of origin, and it was merely possible to make a rough allocation according to rural districts. Nevertheless this provided a pointer for the procedure to be adopted in further studies to be carried out in the beet fields of the rural districts. Special importance was attached to establishing how many spinach leaf miner pupae were present in the soil in a square metre of screened surface, converted to an area of one hectare, in order to draw positive conclusions on the degree of a possible occurrence in the coming year.

The screening of the soil in the beet fields was a long and difficult process. A certain area was dug out to a depth of 8 centimetres between two beet rows in different soils and at different locations (Fig. 5). A simple screening of the field soil proved to be useless because the pupae are always practically unrecognisable in the soil due to the particles of earth clinging to them. This means that they are difficult to find so that they had to be washed with water to free them of soil. A most satisfactory practice was to force the field soil dug out for screening through the screen by applying a water jet at a pressure of 20 to 30 atmospheres gauge (Fig. 6).

The screen used for the purpose of the examination should have high sides which will prevent the earth from being flushed over when the work is done carefully. By means of this method both pupae and remains of emerged pupae of preceding generations will be exposed. The consumption of water required for this practice is, however, very large. For each screening of earth that has to be examined, about 250 litres of water are required to force the soil through

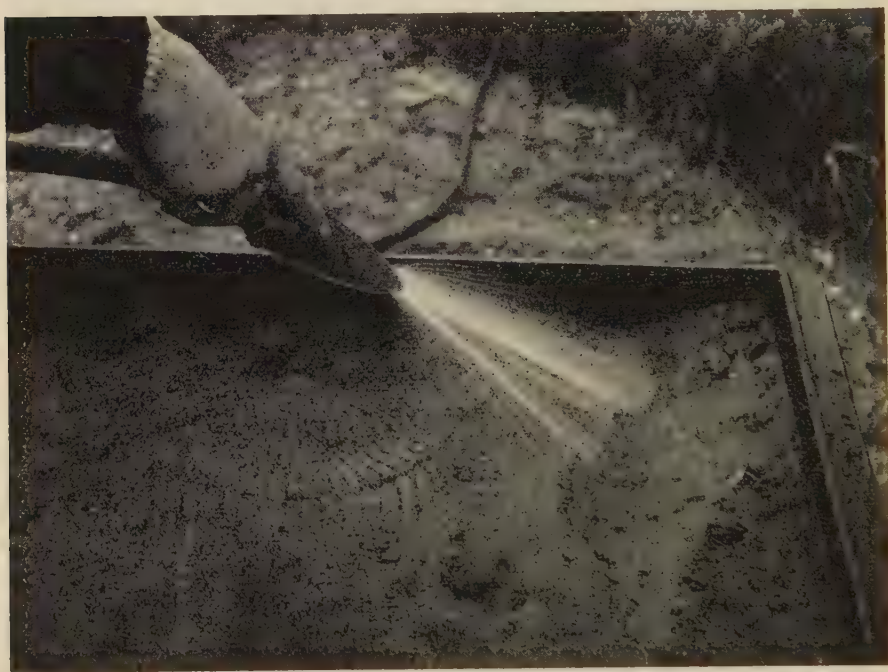


Fig. 6

the mesh. The particles left on the screen have to be probed piece by piece with wooden rods for spinach leaf miner larvae (Fig. 7). It was found during this work that the spinach leaf miner pupae are extremely resistant to the powerful water jet, and are seldom harmed. The findings of pupae, converted to the square metre, and separated according to districts, localities and soil types, are given in Tables 3 and 4.

A striking fact about the results in Table 3 is that in the Frankenthal district all fields consisting of sandy loam were highly populated with pupae. Screening of light sandy soil close to a gravel pit revealed only a small population of pupae, as compared with previous results. Apparently soils which are

Table 3: Soil screenings for presence of spinach leaf miner pupae in Frankenthal district.

Location	Type of soil	Soil depth dug out (cm)	Area sq. m.	No. of living pupae	No. of emerged pupae	Area hectare	No. of living pupae	No. of emerged pupae	Beets
Hefenheim	sandy loam	6—8	1	39	13	1	390 000	130 000	S
Hefenheim	sandy loam	6—8	1	13	—	1	130 000	—	S
Hefenheim	sandy loam	6—8	1	65	26	1	650 000	260 000	S
Hefenheim	sandy loam	6—8	1	26	52	1	260 000	520 000	S
Hefenheim	sandy loam	6—8	1	13	52	1	130 000	520 000	S
Hefenheim	sandy loam	6—8	1	—	65	1	—	650 000	S
Hefenheim	sandy loam	6—8	1	—	10	1	—	100 000	S
Roxheim	sand	6—8	1	1	—	1	10 000	—	F
Roxheim	sand	6—8	1	1	—	1	10 000	—	F

S = sugar beet

F = fodder beet

(In 1957 no spinach leaf miner controls were carried out in any fields)

very light, permeable to water and undergoing rapid change of temperature, are less suited to pupation.

From Table 4 which gives the results of screenings carried out in the Worms district, it is evident that there were few pupae in two loamy sand fields whereas in the third field there was a large population of pupae. This may be explained by the fact that the first two beet fields were sprayed once with

Table 4: Soil screenings for presence of spinach leaf miner pupae in Worms district.

Location	Type of soil	Soil depth dug out (cm)	Area sq. m.	No. of living pupae	No. of emerged pupae	Area hectare	No. of living pupae	No. of emerged pupae	Beets
Eich ¹⁾	loamy soil	10	1	3	4	1	30 000	40 000	S
Eich ¹⁾	loamy soil	6—8	1	0	2	1	—	20 000	S
Eich ²⁾	loamy soil	6—8	1	26	13	1	260 000	130 000	S

1) Spinach leaf miners were controlled with DIPTEREX® in these fields in early Spring.

2) No spinach leaf miner control.

S = Sugar beets

DIPTEREX® against spinach leaf miners and shortly afterwards were treated twice with METASYSTOX® against yellows. The third field was not treated at all.

On October 17, 1957 all the sampled pupae were taken to the laboratory at the regional pest control office, and placed in spinach leaf miner breeding vessels. The first flies emerged on October 21, and more were observed daily. A most interesting discovery was that flies emerged from pupae which were



Fig. 7

sampled from the relatively warm waste water (43°C) at the Offstein sugar factory. Judging from their black colour, it was apparent that about 20 % of the pupae were parasitized. Although this dark pigmentation is not an absolute indication of parasitization, the emergence figures obtained in the breeding vessels (Fig. 3) confirm this percentage. The studies will be continued.

Conclusions

The population density of overwintering pupae in the beet fields appears to be very high, whereas parasitization is slight. Even though the figures obtained were converted theoretically, the regional pest control office must conclude

® = Registered trade mark



Fig. 8

from these that the young beet plants will be heavily attacked by spinach leaf miners in the coming vegetation season. To be on the safe side, it must be assumed that the rate of infestation will not be less than in the previous year.

The beet farmers will therefore have to spray their crops next year as well to protect them against attacks by spinach leaf miners, and it is also essential that crops of fodder beet are included in the treatment.

Pest control workers and farmers must keep a close check on the pest from the very outset. In Rhineland-Pfalz, no precise records are available showing when the pest starts to lay eggs in Spring. The pertinent literature gives details according to which the flight of the spinach leaf miner coincides with the full blossom of geans, and the pest lays its eggs when horse chestnuts begin to bloom. These phenological data still have to be confirmed for Rhineland-Pfalz, and corrected if necessary. It is already obvious that spinach leaf miner controls will be necessary again next year. Beet growers should therefore make

preparations by forming spraying teams, purchasing equipment, making arrangements with spraying contractor firms etc. Moreover the industry, associations and the trade must make preparations for the timely manufacture and sale of insecticides.

The regional pest control office will have to arrange to issue warnings to beet farmers over the radio and in newspapers as soon as it has been established that the pest has started to lay eggs. These warnings must be given promptly so that farmers will be ready to take action against the threatening danger of spinach leaf miner attacks. Serious injury by plant pests can always be prevented when the attacking pest is recognised in good time and necessary control measures are carried out promptly.

Institute for Phytopathology, Bonn University
Director: Professor Dr. H. Braun

Studies on the Overwintering of Powdery Mildew *Podosphaera leucotricha* (Ell. et Ev.) Salm.

by Wilhelm Kosswig

(paper read at IV International Plant Protection Congress 1957, Hamburg)

As a widened conception of the term, overwintering is understood in this paper to mean that period in the life-cycle of the fungus extending from the time of bud infection until these buds emerge in the following Spring.

These studies were conducted from late Summer 1956 until Spring 1957 at the Höfchen Research Station of Messrs. Farbenfabriken Bayer Aktiengesellschaft, Leverkusen, on a total of 2792 annual long shoots of 130 trees of the *Jonathan* variety growing in 4 plots. The rate of mildew incidence in the plots was estimated from the number of terminal buds that died during the Winter, and those which were infected on emerging in Spring. In plots I and Va, incidence was so similar that here the observations can be discussed jointly. According to the percentage of infected and dead buds, the plots may be graded as follows (Table 1):

Plot V:	slight incidence (18.6 %)
Plots I + Va:	moderate incidence (35.7 %)
Plot II:	severe incidence (50.3 %)

When the numbers of infected and dead buds are examined separately, it is observed that there is a uniform increase corresponding to the degree of incidence in the plots (Table 1, Fig. 1). From the parallelism of the increase, it may be concluded that the buds die as a result of infection (see Table 4).

Following the formation of the bud scales, a distinction can be made for terminal buds between closed buds (G) and split buds (A). Aerts and Soe-

Table 1: Höfchen Research Station. Infection of plots. Variety: *Jonathan*.

Plot	Trees	Terminal buds	Infected %	Dead %	Infected and dead %
V	36	764	12.70	5.89	18.59
I + Va	65	1678	21.16	14.54	35.70
II	29	350	27.43	22.86	50.29
Total and mean respectively	130	2792	19.63	13.22	32.84

I	32	839	21.81	13.95	35.76
Va	33	839	20.50	15.14	35.64

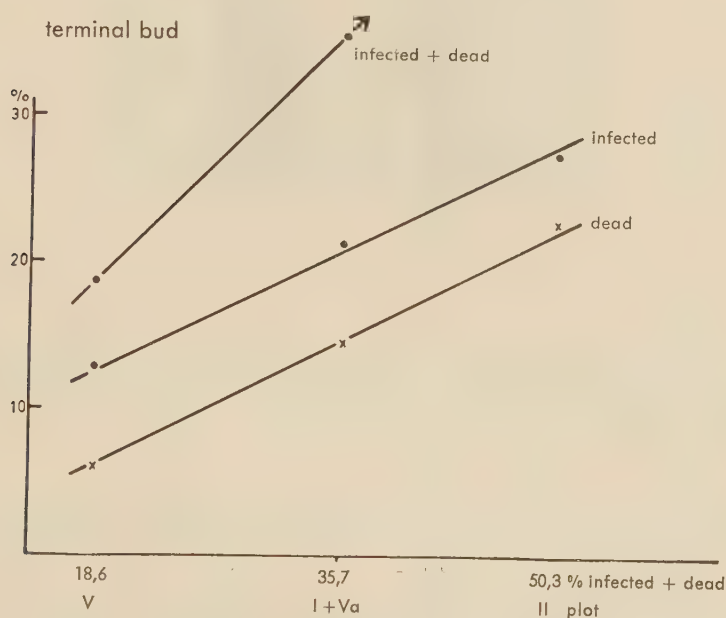


Fig. 1: Terminal buds; infected and dead buds in the different plots

nen (1955, P. 65) recently drew attention to the importance of split buds to the epidemiology of powdery mildew. These authors established that split buds either die (13 %) or are infected (87 %) when they emerge. In my observations, the infection of the plots (Table 2) is determined as expected by the percentage of split buds present.



Fig. 2: Closed (left) and split terminal bud (right) in swelling stage

Up to 27.35 % (plot II) of the closed buds may be infected. The numbers of both dead and infected buds increase proportional to the infection of the plots but the differences between moderate and severe infection (plots I and Va as opposed to plot II) are not significant (Table 3). On the other hand, a high

Table 2: Terminal buds. Percentage of closed (G) and split (A) buds in the plots.

Plot	G + A Total	G (closed) %	A (split) %
V	764	91.62	8.38
I + Va	1678	80.81	19.19
II	350	63.71	36.29
Sum resp. mean	2792	81.63	18.37

percentage of split buds is infected (88.1 % on the average in all plots); as infection becomes more severe, the percentage of dead buds increases, while the percentage of buds infected on emergence decreases (Table 3).

Table 3: Terminal buds. Infection of closed (C) and split (A) buds.

Plot	G (closed)				A (split)			
	No.	infect. %	dead %	infected and dead %	No.	infect. %	dead %	infected and dead %
V	700	6.57	5.71	12.29	64	79.69	7.81	87.50
I + Va	1356	10.55	12.91	23.45	322	65.84	21.43	87.27
II	223	13.00	14.35	27.35	127	52.76	37.80	90.55
Sum resp. mean	2279	9.57	10.84	20.40	513	64.33	23.78	88.11

Table 4: Terminal bud — Comparison of bud infection (microscopic examination) and conditions on emergence of buds.

Plot I + Va	G Terminal bud closed		Sum total	Infected, dis- eased and dead %
	not infected healthy	infected, dis- eased and dead		
micr.	100	21	121	17.4
emergence	820	255	1075	23.7
Sum	920	276	1196	P = 0.14
Plot II	G			
micr.	62	14	76	18.4
emergence	162	61	223	27.4
Sum	224	75	299	P = 0.16
Plot I	A Terminal bud split			
micr.	3	50	53	94.3
emergence	20	127	147	86.4
Sum	23	177	200	P = 0.09*

*direct computation

In agreement with G ä u m a n n (1951), I interpret the increase in the number of dead buds proportional to the increase in the rate of infection among closed and split terminal buds as a necrogenous defensive reaction of the host. In making this assumption, it remains to be checked whether infected buds can recover. Previous evaluations have not provided any clues in this direction. A microscopic comparison of terminal buds examined for infection with the number of buds found to be dead and infected in Spring, did not reveal any difference either among the closed buds or among the split buds (Table 4). This proves that it is a perfectly justified procedure to combine the percentages of infected and dead buds in order to assess the rate of mildew incidence. Further to the report of A e r t s and S o e n e n (1955), it has been established that not all split buds are infected.

It is a known fact that primary-infected shoots are grouped at the ends of the branches. The terminal bud is a particularly outstanding site of infection. The combined results for all plots show that 32.84 % of infected and dead buds are terminals, whereas only 6.22 % of the 1st. axillary buds are infected. From position 2 to 10, an average of 3.44 % of the buds are infected or dead,

Table 5: Bud position and infection (combination of plots).

Bud position	Buds No.	infected %	dead %	infected and dead %
T	2792	19.63	13.22	32.84
1	2409	1.16	5.06	6.22
2	2608	0.58	3.11	3.68
3 + 4	5344	0.43	2.56	2.99
5 + 6	5275	0.23	3.36	3.58
7 + 8	4857	0.06	3.40	3.46
9 + 10	3941	0.05	3.63	3.67
Sum resp. mean	27226	2.33	4.37	6.70

No significance of differences for

infected: 7th. to 10th. bud, common mean 0.06%
dead: 5th. to 10th. bud, common mean 3.42%
infected and dead: 2nd to 10th. bud, common mean 3.44%

these being evenly distributed (Table 5). A further marked difference among the various positions tabulated is perceptible when the percentages of buds infected on emergence and dead buds are recorded separately. The farther the buds are situated from the end of the branch, the smaller is the percentage of infected emerging buds. There is no significant difference between the 7th. and 10th. buds (Table 5). The decreasing trend in mortality is evident as far as the 3rd. and 4th. buds, whereas from the 5th. to 10th. buds the percentage of mortality remains constant at 3.42 % (Table 5). Removal of shoot tips as a

Table 6: Bud position and infection in plots; dead buds.

Bud position	Plot						All plots		Homo-geneity*
	V		I + Va		II				
	Buds No.	dead %	Buds No.	dead %	Buds No.	dead %	Buds No.	dead %	
T	764	5.89	1678	14.54	350	22.86	2792	13.22	***
1	676	3.70	1452	4.61	381	10.68	2409	5.06	***
2	728	1.51	1579	3.17	301	6.64	2608	3.11	***
3-4	1485	0.88	3229	2.73	630	5.56	5344	2.56	***
5-10	3817	1.62	8750	3.84	1506	5.78	14073	3.45	***
Sum resp. mean	7470	2.09	16688	4.71	3068	8.21	27226	4.39	***

*Homogeneity checked with 2×3 index: *** = $P < 0.001$

mechanical control practice against mildew is therefore an important factor in the reduction of primary infections.

Within the different plots, the percentage of dead buds depends upon the severity of the respective infection (Table 6), whereas in the case of infected emerging buds this relation can only be established for the terminal buds (Table 7). The reaction of the terminal bud therefore provides the basis for the epidemiological behaviour of *Podosphaera leucotricha*.

Depending upon their position on the branch, the buds ought to differ in their disposition, as the observations have proved. The buds can be graded

Table 7: Bud position and infection in plots; infected emerging buds.

Bud position	Plot						All plots		Homo-geneity*
	V		I + Va		II		Buds No.	infect. %	
	Buds No.	infect. %	Buds No.	infect. %	Buds No.	infect. %			
T	764	12.70	1678	21.16	350	27.43	2792	19.63	***
1	676	0.74	1452	1.38	381	1.07	2409	1.16	o
2	728	0.41	1579	0.57	301	1.00	2608	0.57	o
3—4	1485	0.34	3229	0.53	630	0.16	5344	0.43	o
5—10	3817	0.21	8750	0.10	1506	0.00	14073	0.12	o
Sum resp. mean	7470	1.58	16688	2.46	3068	3.36	27226	2.32	***

*Homogeneity checked with 2×3 index: *** = $P < 0.001$; o = $P > 0.05$

in three groups with respect to their susceptibility, namely the terminal bud, the 1st. bud, and all following buds. As the quotient obtained for infected and dead buds increases proportional to the basal shift of the bud position, this means that in the same manner the host shows increasing ability to display necrogenous defensive reaction to the infection.

The question now arises whether branches bearing a closed terminal bud (G-branches) react differently from those branches with a split terminal bud (A-branches): On combining the percentages of infected and dead buds, it is found that A-branches are infected more often than G-branches. This difference is evident as far as the 4th. bud. The ability of both branch groups to display defensive reactions varies in the same manner. More terminal buds and 1st. axillary buds die on A-branches than on G-branches. The differences determined from the 2nd. bud onwards are not statistically significant. For buds which survive infection and those buds which are infected on emerging in Spring, the percentage is significantly greater on A-branches up to the 6th

Table 8: Bud position and infection following formation of terminal bud (G and A branches); combination of plots.

Bud position	G-branch with closed terminal bud				A-branch with split terminal bud			
	No.	infect. %	dead %	infected and dead %	No.	infect. %	dead %	infected and dead %
T	2279	9.57	10.84	20.40	513	64.33***	23.78***	88.11***
1	1949	0.31	3.75	4.05	460	4.78***	10.65***	15.43***
2	2128	0.23	2.87	3.10	480	2.08***	4.17	6.25***
3—4	4365	0.23	2.36	2.59	979	1.33***	3.47	4.80***
5—6	4306	0.14	3.23	3.37	969	0.62*	3.92	4.54
7—8	4003	0.025	3.40	3.42	854	0.23	3.40	3.63
9—10	3294	0.030	3.89	3.92	647	0.15	2.32	2.47
Sum	22325				4901			

The significance is given for the difference (G—A) in respect of individual bud positions:

*** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$

bud (Table 8). The extent of the infection, therefore, governs the reaction of the different buds on the branch, and largely determines whether the terminal bud closes or remains open. It may be concluded from this finding that the annual long shoots of a tree also differ in their disposition.

Further facts are brought to light in this respect when a study is made of the relationships between bud infections and secondary infection. Consideration was given at first only to healthy branches and branches with leaf infection because when the shoot axil is infected the buds are in direct contact with the mycelium, with the result that special circumstances ensue.

Stålfelt (1923) maintained that buds are infected as a result of the mycelium penetrating into the leaf buds in early Summer when these buds are not completely covered by scales (cf Braun and Riehm, 1957, P. 247), this emanating from the secondary infections on the leaves. This means that there ought to be more infected buds on secondary-infected branches than on healthy branches. In the case of terminal buds, the percentage of split buds (Table 9) and of diseased and dead buds (Table 10) in the slightly and moderately infected plots (V, I and Va) is significantly greater on secondary-infected branches than on healthy branches. In a severely infected plot (II), however, the differences are well outside the limit of significance (Tables 9, 10), although

Table 9: Secondary infection and split (A) buds in plots.

Plot	Healthy shoots (g)			Shoots with leaf infection (b)			Homo- geneity b—g
	G + A	A	A %	G + A	A	A %	
V	544	17	3.12	219	46	21.00	} o *** * o
I + Va	820	126	15.37	798	154	19.30	
II	138	46	33.33	209	78	37.32	
Sum resp. mean	1502	189	12.58	1226	278	22.68	***

Significance of difference b—g: *** = $P < 0.001$; ** = $P < 0.01$; * = $P < 0.05$; o = $P > 0.05$

it was just in this case that very marked differences ought to have been evident. For the 1st. bud, infections on healthy and diseased branches are equally frequent. The same applies to the 2nd. to 10th. buds (Table 10). It is not until the results are combined for all plots that it is found that buds on secondary-infected branches are more frequently attacked (1st. bud 4.92 as opposed to 7.00 %, 2nd.-10th. bud 2.86 in contrast to 3.86 % [Table 10]). Two conclusions may be drawn from this. Firstly, buds which are attacked on healthy branches (cf H e r v e r t, 1954) cannot be infected by mycelium. Secondly, the conformity for both groups of branches shows that attack of buds is not dependent upon infection of leaves, which also indicates that buds are infected by conidia, as already assumed by other authors (e. g. F i s c h e r, 1956, P. 235). The "conidial infection", therefore, governs the infection of buds whereas the "mycelium infection" is only of secondary importance. Further proof of this is given by the fact that for the 2nd. to 10th. buds, the differences in infection are slightest particularly in the most severely infected plot II, which is clearly evident from the increase in P-values proportional to the increase in the rate of infection (Table 10). It is also pointed out — although this has still to be proved by exact figures — that the bracts of those buds most frequently infected, namely the terminal bud and the 1st. axillary bud, are much less often secondary-infected than the bracts of the 2nd. to 10th. buds. The higher rate of bud

Table 10: Secondary infection and reaction of buds of different positions in plots.

Bud position	Plot	Healthy shoots (g)			Shoots with leaf infection (b)			Homo-geneity (b - g) P ⁵⁾
		No.		infected and dead %	No.		infected and dead %	
		total	infected and dead		total	infected and dead		
Terminal bud	V	544	71	13.05	219	70	31.96	< 0.00001
	I + Va	820	253	30.85	798	299	37.47	0.006
	II	138	68	49.28	209	107	51.20	0.81
	Sum resp. mean	1502	392	26.10	1226	476	38.83	< 0.00001
1st. bud	V	487	20	4.11	188	9	4.79	0.86
	I + Va	723	34	4.70	673	42	6.24	0.25
	II	111	11	9.91	167	21	12.57	0.63
	Sum resp. mean	1321	65	4.92	1028	72	7.00	0.040 (0.0005) 2)
2nd.—10th. bud ¹⁾	V	4308	59	1.37	1713	38	2.22	0.066 ³⁾
	I + Va	6594	226	3.43	6475	244	3.77	0.10 ³⁾
	II	1039	56	5.39	1379	87	6.31	0.61 ³⁾
	Sum resp. mean	11941	341	2.86	9567	369	3.86	0.0004 ³⁾ (< 0.00001) 4)

1) 5 positions: 2, 3—4, 5—6, 7—8, 9—10

2) 2×6 index

3) 2×10 index

4) 2×30 index

5) Terminal bud and 1st. bud 2×2 index

infection on branches with leaf infection is explained by the presence of more conidia on these branches. Thus it is understandable that as the secondary infection increases, differences in infection rates on the two groups of branches should disappear because following this increase there is a more even distribution of conidia on the tree.

Direct attack of axillary buds, however, surely is not the only way in which these buds are infected. According to the investigations conducted by Aerts and Soenen (1955), periods of secondary infections must be reckoned with between early May and the middle of August. These periods coincide with the peaks in the conidial production of the fungus. But elongation growth of healthy branches is not completed until the middle to the end of July. This means that conidial infections must also take place on the growing cone from

which — depending upon adhesion of infection in the primordials — healthy or infected buds develop; it would then be assumed that there is also a varying disposition among the primordials corresponding to the varying reaction to infection at the different bud positions. The evaluation of a few results obtained in observations shows that in this respect infection of axillary buds determines whether the terminal bud remains healthy, emerges infected or dies in the coming Spring. The more severe the infection of axillary buds, the greater will be the probability of the terminal bud dying. In cases where infection is slight, the percentage of surviving infected buds or the ratio of dead to infected buds determines the condition of the terminal bud. When most of the infected axillary buds die, the terminal bud usually remains healthy. But when the percentage of buds which survive infection is equal to the percentage that die following infection, the terminal bud also becomes infected (Table 11); the formation of split buds would then be largely parallel to this.

Table 11: Infection of subsequent buds and reaction of terminal bud (healthy branches and branches with leaf infection); plot I, row 11 (16 trees).

Buds 1—5		Terminal bud (G + A)		
		healthy	infected	dead
No.	healthy	1015	387	203
	infected	1 } 35	7 } 16	4 } 17
	dead	34 }	9 }	13 }
%	infected	0.10	1.74	1.82
	dead	3.24	2.23	5.91
	infected + dead	3.33	3.97	7.73
dead : infected		3.40	1.3	3.2

= symbol means difference not significant

Field control of mildew:

1. The object of chemical controls is to prevent formation of conidia. The crucial period for the application of chemicals is in May and June; according to Aerts and Soenen (1955) it is during these two months that conidial production reaches a high level, and moreover conditions at this time of the year are favourable for infection.
2. Mechanical control serves the purpose of augmenting chemical controls; it is sufficient to remove the terminal bud and the first axillary buds. When buds are cut back in Winter, special attention must be given to branches with split terminal buds. Following emergence, primary-infected shoots must be removed by the end of April.

Summary

1. Studies were conducted from late Summer 1956 until Spring 1957 on annual long shoots of the *Jonathan* variety.
2. The buds and branches differ in their disposition to *Podosphaera leucotricha*.
3. The buds and the growing cone are infected mainly by conidia.
4. The reaction of the terminal bud (healthy, infected on emerging, dead) is with great probability determined by the infection and reaction of the axillary buds.

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Biology, Ecology and Control of Senn Pest, *Eurygaster integriceps*, in Turkey (1955/56)

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I. Occurrence

The senn pest species *Eurygaster* sp. and *Aelia* sp. cause severe damage to cereals in Turkey. The main regions of infestation are in South-East and Central Anatolia. The major senn pest species occurring in the vilayets of Diyarbakir, Urfa, Adiyaman, Siirt, Mardin and Elazig in South-East Anatolia is *Eurygaster integriceps* whereas in Central Anatolia crops are attacked chiefly by *Aelia* sp.; in this latter region, *Eurygaster integriceps* also occurs but is less abundant. In the province of Funceli crops are infested by *Eurygaster austriaca* although this species is of lesser importance because in contrast to *E. integriceps* it is not distributed on a large scale.

II. Damage

Since 1950, *Eurygaster integriceps* has become increasingly abundant in South-East Anatolia where it causes severe damage. Prior to 1950, farming in this particular region had been restricted mainly to cattle breeding and only a small acreage of land suitable for cultivation was used for growing cereals. But with the introduction of tractors and other mechanical aids to farmers, cultivation of cereals was greatly intensified and expanded. Before the acreage of grain crops was enlarged, *Eurygaster integriceps* fed on wild gramineous plants which, however, withered at the beginning of Summer. Consequently greater distribution of senn pest was prevented. However, as the pests found equivalent or better feeding conditions in the expanding grain-fields once the natural vegetation had died, the senn pest population grew appreciably. By 1954/55, *E. integriceps* had become a major problem of crop protection. The damage recorded in that particular season increased to 94—100 % as compared with 3 % in the preceding years. It must also be considered that when a sample of cereals contains only 2 % damaged grains, the baking quality of the flour yielded from these grains is significantly lowered.

In 1955 and 1956, grain samples obtained from different provinces in Turkey were examined for infestation (to establish whether they had been sucked or not by the pest). The results of these examinations are given in Table 1 from which it is evident how high the percentage of damage was in the different areas of infestation in 1955 and 1956.

In Spring 1956, a survey of damage was carried out in six different districts; the results registered are given in Tables 2 and 3. To conduct these studies, use was made of wire cages 2 square metres in size, under which wheat of the Florence variety was sown. Adults which had migrated from the overwintering grounds were used as test insects. The injuries established are entered as percentages in Tables 2 and 3.

Table 1: Damage caused by *Eurygaster integriceps* to kernels (expressed in %).
Samples from different vilayets in Turkey.

Province	Vilayet	No. of samples		Damage	
		1955	1956	1955	1956
Diyarbakir	Merkez	14	57	39.6	38
Diyarbakir	Bismil	39	44	12.6	52.4
Diyarbakir	Mermer	25	—	78.6	—
Diyarbakir	Cinar	46	59	3.3	76.4
Diyarbakir	Ergani	79	2	23	—
Diyarbakir	Silvan	52	31	60.7	10.5
Diyarbakir	Hazro	5	—	66.4	—
Diyarbakir	Cermik	10	—	65	—
Urfa	Siverek	16	38	44.7	13
Urfa	Hilvan	21	28	46.7	53.2
Urfa	Bozova	—	42	—	90.6
Siirt		3	—	4.1	—
Siirt	Besiri	—	37	—	10.7
Siirt	Batman	—	39	—	36
Siirt	Kurtalan	—	40	—	17.1
Mardin	Mazidagi	—	3	—	42.6
Mardin	Derik	—	6	—	29.3
Mardin	Savur	—	3	—	5.1

Tests were conducted in 1956 to ascertain the damage caused to kernels, using 1 square metre cages set out in the wheat fields (Florence variety). Larvae in the 1st. and 2nd. ecdyses were placed in these cages and left there until reaching the imaginal stage. Table 4 gives the recorded values expressed in percent for an increasing larval population per square metre. The greater the population of larvae per unit of area or per plant, the more severe is the damage

Table 2: Abundance of *Eurygaster integriceps* and damage caused in six districts in Spring 1956 (damage expressed in %).

Cereal	Acreage	Date of check	No of senn pests per sq. m.	Damage in %
Wheat	15 Dekar*	28. 5. 56	6.8	68.5
Barley	120	28. 5. 56	2.8	37.9
Wheat	95	29. 5. 56	3.5	51.1
Wheat	150	29. 5. 56	4.4	51.6
Wheat	10	28. 5. 56	1.3	46.5
Barley	40	28. 5. 56	1.0	36.2

* 1 Dekar = 0.1 hectare = 0.247 acre



Area of *Eurygaster* infestation in South-East Anatolia

Fig. 1

inflicted. For a population density of 2 larvae per head of grain, the damage caused is approximately in the same order of magnitude as for a population density of 4 or 8 larvae per head.

III. Biology

A. Overwintering

The infestation zone (see Fig. 1) stretches as far as the province of Adiyaman in the west and the Euphrat Valley in the east while in the north it is bordered by a range of mountains. The country in the infestation area is slightly hilly, the soil very loamy and fertile. The mountains are overgrown mainly by weeds (*Acantholimon* and *Astragalus* species), and serve as the overwintering grounds for the pests which hibernate on or in the soil in the root area of the above-mentioned weeds. Depending upon their size and genus, 10 to 50 and sometimes up to 250 senn pests overwinter on one plant. The duration of hibernation extends over a period of about nine months (from about the middle of June until March the following year). Usually the overwintering grounds are 20 to 100 kilometres away from the infestation zones.

Table 3: Distribution of *Eurygaster integriceps* and average damage on heads of grain (with two replications).

No. of senn pests distributed on a head	Average damage in %
2	31.3
4	29.3
8	37.5
16	40.8

Table 4: Population density of larvae per unit of area and resulting damage (with two replications).

No. of larvae per sq. m.	Percentage damage of sucked kernels
5	10.5
10	21
20	27.5
40	47

In 1955/56, counts of population density in the overwintering grounds were carried out to obtain an indication of infestation in the attacked areas. The results are given in Table 5. It is evident from this table that the winter population in 1956 was greater than in 1955. Furthermore the senn pest populations had continued to increase.

A study of senn pests at overwintering places with a moist soil showed that there was a relatively high percentage of dead pests. On heavy, wet soil, 45 dead and 20 living pests were observed, for example, while on dry soil 1 dead and 24 living pentatomids were found. The high rate of mortality on moist soil is attributed to a) lack of food for adults, b) attack by fungi (parasites) and Diptera (endoparasites). Mortality in the overwintering grounds usually averages about 35 % (between 25 and 46 %). Mortality caused by fly parasites amounted to between 3 and 25 %.

Table 5: Counts of *Eurygaster integriceps* to determine the population density in the overwintering grounds.

Province	Vilayet	Mountains	Average infestation by <i>E. integriceps</i>			Degree of infestation rising (+) decreasing (—)
			1954	1955	1956	
Adiyaman	Gerger	Haydaran	—	28.2	37.1	+
Adiyaman	Gerger	Kimil	—	68.0	97.3	+
Adiyaman	Kahta	Nemrut	—	34.6	41.2	+
Adiyaman	Celikan	Ulababa	—	23.1	33.7	+
Malatya	Pötürge	Meydan	—	175.7	18.0	—
Malatya	Pötürge	Ulubaba	—	165.7	27.9	—
Elazig	Sivrice	Hazarbaba	95.7	8.0	5.5	—
Elazig	Maden	Sepken	—	7.5	68.5	+
Elazig	Mastar	—	102.8	66.0	43.6	—
Elazig	Mastar	Rute	—	18.0	22.8	+
Elazig	Mastar	Runik	—	209.0	43.6	—
Elazig	Mastar	Mezgetin	266.4	261.0	125.6	—
Elazig	Mastar	Kebensuvar	354.5	426.0	66.9	—
Elazig	Mastar	Hasdug	73.4	424.0	73.2	—
Diyarbakir	Merkez	Karacadag	—	10.0	30.2	+
Diyarbakir	Lice	Zengisor	51.5	—	85.6	+
Diyarbakir	Lice	Köz	159.0	37.4	111.2	+
Diyarbakir	Lice	Dizbir	106.0	30.9	66.9	+
Diyarbakir	Lice	List	91.5	89.7	92.0	+
Diyarbakir	Lice	Cekem	164.5	—	—	—
Diyarbakir	Kulp	Andok	7.3	10.3	1.0	—
Diyarbakir	Kulp	Berhiv	3.8	15.0	5.1	—
Diyarbakir	Kulp	Kozman	0.5	39.8	0.2	—
Diyarbakir	Cüngüs	Savurcak	310.0	77.0	141.3	+
Diyarbakir	Cüngüs	Hasanpasa	187.0	60.7	96.5	+
Diyarbakir	Cüngüs	Polatusagi	136.2	73.6	101.1	+
	Cüngüs	Piran	89.5	49.6	75.1	+
Mardin	Cizre	Cudi	267.8	12.8	21.7	+
Mardin	Mazidagi	Mazidagi	—	8.0	8.8	+
Mardin	Sason	Sason	2.0	96.6	31.3	—
Mardin	Sirnak	Sirnak	32.8	36.5	24.3	—
Mardin	Eruh	Cirav	—	36.5	24.3	—

In the vicinity of Diyarbakir, the pentatomids do not always migrate to the mountains to hibernate; in this particular region they can also overwinter at high locations at an altitude of about 850 to 860 metres in the cultivated areas on the roots of bush oaks, grape vines and other plants.

Depending upon climatic conditions in each particular year, the migratory flight of senn pests from the overwintering areas in the mountains to the plains usually takes place when the snow begins to melt. At this time, the pests feed in the plains on fallow fields, on pastures or even in the grainfields. The wild grasses which up to now have always served as hosts to the senn pest, wither in early Spring, and the insects then move to the neighbouring grainfields where they remain until the new generation has developed.

B. Development

The climate in the infestation zone is very favourable for the development and reproduction of *E. integriceps*. The average amount of rainfall (22 years) was recorded at 469 mm. In April the average relative humidity is 61 % and in May 55 %. Measurements of temperature showed a mean of 13.8° C for April and 19.5° C for May. In 1955 and 1956, the overwintering pests migrated into the infestation zones from March 20 onwards at a mean temperature of 8.2° C and an average relative humidity of 60.7 %. Immediately after the flight from the overwintering grounds — the insects are then rather exhausted — the senn pests begin to suck greedily on the stems of cereals and on wild gramineous plants. One sucking may last from 5 to 42 minutes. Then the insects rest. While they are feeding on the plant, the pests introduce secretions into the stems, which cause the death of the ears and prevent the formation of kernels. This type of damage is known as "kurtbogaz", and is most appreciable in the province of Diyarbakir.

After the overwintered pests have fed in the fields for a time, copulation takes place followed by oviposition. The eggs are laid on different wild gramineous plants (leaves and stems), and later also on cereals, usually in two files and sometimes in three parallel files. Each batch contains an average of 12 to 14 eggs.

In 1955 the first egg batches were found in Diyarbakir on April 13, and in 1956 on April 18. The larvae began to emerge about April 23 in 1955, and around May 1 in 1956. Oviposition continued in 1956 until June 5. In the climatic conditions prevailing in Diyarbakir, the ovipositional period for one insect lasts about 10 to 12 days. 20 young pests of the new generation were found to one overwintered adult in early June, 1956.

Table 6 gives the development periods for the different stages. During the development of these stages, a mean temperature minimum of 15.6° C, a mean temperature maximum of 56° C and an average relative humidity of 30 % were recorded.

When the development periods listed in Table 6 are added to the embryonic development, this gives a total period of development from oviposition to the fully grown insect of 45 to 47 days. During the 1st. and 2nd. instars the larvae feed on the green parts of gramineous plants, mainly by sucking the stems; after the 3rd. instar they move up to the heads and feed on the young kernels. When the larvae are compelled to obtain food only from the stems, they die after the 3rd. moult. From this it is concluded that food from vegetative

plant parts is not sufficient for the full development of the pest so that larvae are dependent upon being able to feed on the growing kernels in order to mature to the adult stage.

Between 0 and 500 larvae were counted per square metre in 1955/56. Infestation fluctuated most considerably. A maximum of 55 larvae were counted per head.

Table 6: Development periods for *Eurygaster integriceps*.

Breed No.	1st. moult	2nd. moult	3rd. moult	4th. moult	5th. moult (adult)
1	25. 5. 56	1. 6. 56	3. 6. 56	10. 6. 56	16. 6. 56
2	25. 6. 56	1. 6. 56	6. 6. 56	11. 6. 56	19. 6. 56
3	25. 6. 56	1. 6. 56	4. 6. 56	11. 6. 56	17. 6. 56
4	25. 5. 56	31. 5. 56	5. 6. 56	9. 6. 56	15. 6. 56
5	26. 5. 56	2. 6. 56	6. 6. 56	11. 6. 56	18. 6. 56
6	25. 5. 56	1. 6. 56	6. 6. 56	12. 6. 56	18. 6. 56
7	24. 5. 56	1. 6. 56	6. 6. 56	11. 6. 56	20. 6. 56
8	24. 5. 56	31. 5. 56	7. 6. 56	11. 6. 56	18. 6. 56

Table 7: Quantities of destroyed *Eurygaster* sp. from 1928—1956.

Year	Quantities of destroyed <i>Eurygaster</i> sp.
1928	90 455 kg
1929	409 867 "
1930	214 855 "
1931—1935 no controls took place	
1936	4 172 "
1937	384 "
1938 no controls	
1939	160 "
1940 no controls	
1941	2 339 141 "
1942	1 305 008 "
1943	342 582 "
1944	222 310 "
1945	45 696 "
1946	22 530 "
1947	481 145 "
1948	222 198 "
1949	785 019 "
1950	166 280 "
1951	1 042 045 "
1952	581 435 "
1953	758 882 "
1954	497 212 "
1955	670 000 "
1956	756 000 "

Mention should be made of the following important observation of significance for selecting a suitable time for control.

During the hot hours of the day the insects remain in cracks in the ground, and return to the plants and heads towards evening when it is cooler. Even light winds disturb the insects and they immediately take shelter under leaves on the ground or in cracks in the ground. This means that insecticides should not be applied during the hot hours of the day or on windy days in order to give an effective control of senn pests.

IV. Control of *Eurygaster* in Turkey

Before insecticides were used, efforts to control senn pest were confined primarily to the mechanical eradication of the insect in the wintering areas, and campaigns were organized to smoke out or burn the pests. This method did not produce good results, and consequently it was discarded. The last time this type of control was carried out was in 1956.

Since then attempts were made to prevent or minimize infestation in the grainfields by collecting adults from fields, either by hand or mechanical devices, and destroying them, or else efforts were limited to preventing total damage to crops by harvesting them early. According to the Turkish Ministry of Agriculture, the quantities of senn pests listed in Table 7 were killed between 1928 and 1956 by the collecting method.

A. Chemical control 1955

The tests were carried out in wire cages measuring $1 \times 2 \times 1.25$ metres (ground area of 2 square metres), set out in cultivated fields. Firstly a number of insecticides were tested in these cages, and later the most promising of these were further tested for efficacy on areas measuring 20 to 25 dekar (1 dekar = 0.1 hectare).

The pests were placed in the cages 24 hours prior to treatment, and sprayed by means of a small hand-operated sprayer. Dusts were applied by means of a gauze bag. Evaluation was carried out three days after treatment with phosphoric ester preparations, and five days after applications of products containing DDT. The results of these 1955 tests carried out in cages are given in Tables 8 and 9 which include only products that produced an effect.

As already mentioned above, those products which proved most effective in the cage tests were applied in the field. A large-scale control operation was carried out against the senn pest with the assistance of a wide organisation. In Spring 1955 there was a heavy fall of rain so that vegetation generally developed rapidly and well which meant that good feeding conditions were provided for the pentatomids flying from the mountains into the grainfields. Consequently the pests reproduced in very large numbers, and their development progressed just as favourably as that of the flora. As a result a big population of *Eurygaster* grew up in 1955, and therefore severe infestation was anticipated for 1956.

The effective products were applied in 1955 in the provinces of Urfa, Diyarbakir and Siirt, over an area measuring 24,600 hectares. In addition to Diazinon, the tests included several formulations containing Parathion, and

also CHLORTHION®. As some of the products used were poisonous and moreover since the farming population had no previous experience in the handling of crop protection products, the control operation was carried out with the assistance of military personnel. The most effective products were those containing Parathion, which gave kills of between 90 and 99 %. Diazinon gave a mortality of 65 to 82 %.

B. Chemical control 1956

Just as in 1955, wire cage-field tests were also conducted in 1956. These tests, in contrast to those of 1955, were carried out in more favourable conditions and on a larger scale. Sprays were chiefly used. The control was carried out in two test series; in the first series, pests migrating from the mountains to the grain-fields were controlled whereas in the second series applications were directed against larvae and imagines of the new generation. The test procedure was the

Table 8: Mortality of *Eurygaster integriceps* given by different insecticides in 1955.

Name of product	Rate of application in grammes or ccs per hectare	Efficacy
METASYSTOX® (50 % active ingredient)	600	99.9
SYSTOX® (50 % active ingredient)	600	98.5
CHLORTHION (50 % active ingredient)	1 400	97.0
CHLORTHION-Staub (3 % active ingredient)	30 kg	95.0
OMPA	600	90.9
Diazinon (20 % active ingredient)	4 500	81.5
Parathion A *	300 active ingredient	63.0
Parathion B *	300 active ingredient	63.0
Parathion C *	300 active ingredient	62.0
Parathion D *	2 000	51.8

* Parathion supplied by different manufacturers.

Table 9: Effects of several insecticides on 3rd. and 4th. instar larvae in wire cage tests.

Name of product	Dosage in grammes or ccs per hectare	in 2 × 2 sq. m. cages		Damage in %
		No. of larvae exposed to test	No. of heads counted	
CHLORTHION (50 %)	1 300	300	360	1.5
Diazinon (20 %)	4 500	300	380	18.0
untreated	—	300	235	47.5
DDT	5 000 active ingredient	150	280	3.0
untreated	—	150	280	26.5

Table 10: Results of aircraft controls against *Eurygaster* in 1956.

Name of product	0/0	Dosage g or cc's of product per hectare	Liquid per hectare expres. in litres	Development stage of pest	Location	Date of test	Effi-cacy in 0/0
CHLORTHION	50	1250	60	3rd—5th larv. stage	Millisaray	25. 5.	98.7
"	50	1400	60	adults of old gen.	Meteris	1. 5.	97.8
"	50	1400	60	" " " "	Bismil	7. 5.	96.4
Parathion	25	1400	60	3rd—5th larv. stage	Millisaray	25. 5.	99.2
Diazinon + CHLORTHION	20	2500	60	larvae, final stage	Arapaslanoglu	15. 6.	94.4
	50	650					
Diazinon + CHLORTHION	20	2500	60	" " "	Tilalo	15. 6.	93.8
	50	650					
DDT	25	201	60	3rd—5th larv. stage	Millisaray	25. 6.	93.0
CHLORTHION	50	1250	60	adults of old gen.	Meteris	1. 5.	92.2
Parathion	25	1200	60	3rd—5th larv. stage	Millisaray	25. 5.	91.4
Diazinon + CHLORTHION	20	2500	60	larvae, final stage	Yabaci	15. 6.	90.3
	50	650					
DDT		2000	60	adults of old gen.	Karabas	14. 5.	90.3
CHLORTHION	50	1000	40	" " " "	Bismil	7. 5.	89.4
"	50	1000	60	" " " "	Bismil	7. 5.	85.7
Malathion	50	3000	60	3rd—5th larv. stage	Millisaray	25. 5.	84.8
Diazinon + CHLORTHION	20	2500	60	larvae, final stage	Bozopinar	16. 6.	83.6
	50	650					
CHLORTHION	50	1400	40	adults of old gen.	Bismil	7. 5.	83.3
Diazinon + CHLORTHION	20	2500	60	larvae, final stage	Dikini	6. 6.	81.0
	50	650					
DDT	25	151	60	3rd—5th larv. stage	Millisaray	25. 5.	80.0
Diazinon	20	4000	60	adults of old gen.	Meteris	26. 4.	79.3
DDT	25	151	60	" " " "	Karabas	14. 5.	75.9
Diazinon	20	4000	60	" " " "	Meteris	27. 4.	75.2
"	20	4000	60	" " " "	Meteris	27. 4.	70.9
"	20	3500	60	" " " "	Meteris	27. 4.	65.9
"	20	4000	60	" " " "	Bismil	7. 5.	65.5
"	20	4000	40	" " " "	Bismil	7. 5.	63.1
Malathion	50	3000	40	" " " "	Bismil	7. 5.	60.5
Diazinon	20	4500	60	3rd—5th larv. stage	Aktepe	2. 6.	57.6
Malathion	50	1750	40	adults of old gen.	Bismil	7. 5.	57.5
Diazinon	20	3500	60	" " " "	Meteris	26. 4.	57.1
"	20	3500	60	" " " "	Meteris	27. 4.	47.1
"	20	5000	60	larvae, final stage	Hücceti	5. 6.	47.1
Malathion WP		40 kg	60	" " "	Karaköprü	6. 6.	37.2
" "		50 kg	60	" " "	Karaköprü	6. 6.	29.0

Table 11: Results of 1956 tests against old generation.

Name of product	Active ingredient content in %	Formulation	Dosage g or ccs active ingredient per hectare	Date of test	Efficiency in %
DICONTAL ®	12 DIPTEREX 12 CHLORTHION	W. P.	360 DIPTEREX 360 CHLORTHION	28. 4.	98.8
Parathion	20	Emulsion	250	27. 4.	98.8
Parathion	20	Emulsion	900	27. 4.	98.7
CHLORTHION	50	Emulsion	700	1. 5.	97.8
DIPTEREX ®	50	W. P.	1000	28. 4.	95.5
DDT+ BHC	25 + 3	Emulsion	5000	27. 4.	95.1
Parathion + Malathion	20 + 50	Emulsion	450 + 1125	27. 4.	94.9
CHLORTHION	50	Emulsion	625	1. 5.	92.2
DICONTAL	12 DIPTEREX 12 CHLORTHION	W. P.	240 DIPTEREX 240 CHLORTHION	27. 4.	91.6
CHLORTHION	50	Emulsion	500	27. 4.	89.4
DDT	30	Emulsion	1800	27. 4.	83.9
DDT	25	Emulsion	3750	7. 5.	75.9
Diazinon	20 + 5 DDT	Emulsion	80 Diazinon 20 DDT	27. 4.	73.0
DDT	10	W. P.	5000	27. 4.	70.4
DDT	50	W. P.	5000	27. 4.	70.2
GUSATHION ®	20	Emulsoin	400	28. 4.	63.2
DDT	25	Emulsion	600	7. 5.	60.5
Malathion	20	Emulsion	450	7. 5.	57.5
Malathion	20	Emulsion	350	7. 5.	57.1
Diazinon	20 + 3 DDT	Emulsion	700 Diazinon 175 DDT	27. 4.	56.5

same as in 1955. The evaluation, however, was carried out with particular thoroughness, and in order to obtain exact data small holes were dug out to a depth of 10 to 20 centimetres in which the pests gathered. In the field, counts were made by the square metre method; insects resting on the cereal plant stems and leaves, as well as those concealed in cracks in the ground or under foliage were included in the count.

In the aerial treatments, the airplanes were flown at normal altitude, and the test plots were measured out so that they were not too large.

The results of these 1956 tests are compiled in Tables 10 and 11.

® = Registered Trade Mark.

Other results of tests conducted with different products against isolated pests are given in Table 9. In these particular tests, healthy wheat plants which had not been sucked by pests were planted out in wire cages, and colonized by a certain number of 3rd. and 4th. instar larvae. Later, these plants were treated and then the kernels were evaluated; the damage caused is given in percent in Table 9. The best results in these tests were given by CHLORTHION applied at a rate of 130 ccs of preparation per dekar. It is intended to repeat these tests in the coming year, using different products.

C. Control operation 1956

This control was the greatest operation of its kind ever carried out in Turkey. It was conducted in the provinces of Diyarbakir, Adiyaman, Urfa and Siirt. To ensure smooth operation of the 30 available aircraft, 20 runways were built in Urfa, 65 in Diyarbakir, 4 in Adiyaman and 6 in Siirt. The operation was started on May 2, 1956 in the province of Urfa.

Use was made primarily of highly effective products with a good initial action. They were applied at a time when about 50 % of the larvae were in the 3rd. moult. 51,800 hectares of grainfields were treated altogether, and 22,497 kilos of CHLORTHION Emulsion (50 %) and 162,587 kilos of Diazinon Emulsion (20 %) were applied. CHLORTHION gave the best effect against both larvae and adults.

In 1955 and 1956, controls of *Eurygaster* were carried out in only one part of the infestation area. Pastureland was primarily left untreated but so too were many cultivated fields. For this reason it was not possible to give the grain crops 100 % protection despite the use of effective insecticides. In several cases, the damage in treated fields was as great as in untreated crops, which may be explained by the fact that the pests moved from the untreated areas to the treated fields after the effect of the products had already lessened. There are many reasons for the migration of the pests from the untreated to the treated fields. Firstly, pastureland close to the wheat fields was mown thus depriving the pests of food so that they were forced to move to the wheat fields in search of new feeding grounds. The early mowing of barley also caused the pentatomids to migrate. Secondly, the senn pests found little food in the early ripening grainfields and consequently attacked late varieties all the more severely.

D. Control programme 1957

In 1957, it is planned to treat an area of 25,000 hectares using 21 aircraft to apply 10 % DDT dust and DIPTEREX dust. The treatment will include cultivated and uncultivated fields especially in order to prevent migration. Applications of DDT will be started when the larvae are in the 1st. moult, and continued until the 4th. moult. From this stage onwards, DIPTEREX dust will be used.